A Marine Preserve Network in San Juan Channel: Is it Working for Nearshore Rocky Reef Fish?

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Background

Marine protected areas (MPAs) have recently been defined as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or has regulations to provide lasting protection for part or all of the natural and cultural resources within" (Presidential Executive Order 13158, 2000). Specific types of MPAs are being called for to protect habitat and promote recovery of fish stocks (Parker and others 2000) and have been heralded as a method for increasing fishery yields (Alcala and Russ 1990). In addition, MPAs have been shown to contain greater reproductive potential of targeted species than non-reserve areas (Palsson 1998).

A marine reserve is a particular type of MPA that specifically restricts fishing activity. Marine reserve theory predicts that conservation of broodstock in certain areas increases production of larvae and juveniles that are exported to the surrounding area. This will cause total biomass and landings in exploited fisheries to increase and length frequency distributions to shift upward (Bohnsack 1996; Ballantine 1994). This 'reserve effect' should be especially evident for long-lived species with high site-fidelity and increasing fecundity with age—such as rockfish (Bloeser 1999). However, this effect has yet to be empirically demonstrated for many species and ecosystems.

Most research on marine reserves to date has taken place in tropical systems. Studies have shown temporal increases in abundance and size of fish in marine reserves on tropical reefs (Alcala and Russ 1990; Roberts and Polunin 1991), and export of adult biomass outside reserves (Russ and Alcala 1997). A handful of studies have tested the influence of marine reserves on nearshore rocky reef fish assemblages in temperate regions (McCormick and Choat 1987; Palsson and Pacunski 1995; Paddack 1996; Palsson 1998). However, these temperate studies have relied on comparisons of 'fished' and 'reserve' sites with (1) little or no replication of treatments or (2) across limited time scales.

Introduction

Data presented here was collected from six sites, three reserves and three non-reserves, in San Juan Channel during July 27 to October 5, 2000. In addition, historical data collected by a similar technique in San Juan Channel during 1974 to 1976 by Moulton (1977) was used for comparison. The eight target species for which data was collected include five rockfish; copper (*Sebastes caurinus*), quillback (*Sebastes maliger*), black (*Sebastes melanops)*, yellowtail (*Sebastes flavidus*), and Puget Sound (*Sebastes emphaeus*); and lingcod (*Ophiodon elongatus*), kelp greenling (*Hexagrammos decagrammus*) and striped surfperch (*Embiotoca lateralis*). These species are distributed over a gradient of susceptibility and desirability to local angler effort. They comprise the largest and most conspicuous members of the nearshore rocky reef fish assemblage in San Juan Channel.

The San Juan Islands Marine Preserves were formed in 1990 and restrict all forms of fishing except for salmon, herring and, in certain areas, crab (Murray 1998). However, this fishing activity probably has little impact on rocky reef fish. Anglers targeting the two pelagic species have very little interaction with rocky reef fish (with the exception of *S. melanops* and *S. flavidus*) and crabs are fished with pots and usually in soft bottom habitats. Directed commercial fisheries for rockfish using jig and troll gears were prohibited in the San Juan Islands in 1984. Commercial trawling is allowed (outside reserves), but rarely occurs in San Juan Channel, and has resulted in total annual rockfish catches of less than 100 pounds since 1994. No lingcod have been caught commercially during the last few years (Palsson *and others* 1997).

Analyses of temporal patterns of fish density at one reserve site since 1974 have shown: small, steady increases in copper rockfish (*S. caurinus*) and kelp greenling (*H. decagrammus*), a large increase in Puget

Sound rockfish (*S. emphaeus*), fluctuations in lingcod (*O. elongatus*) with current abundance similar to mid 1970s levels, a large decrease in quillback rockfish (*S. maliger*), and the disappearance of yellowtail rockfish (*S. flavidus*) and black rockfish (*S. melanops*) (Moulton 1977; Caselle 1987; Gregg and Eisenhardt, unpublished data).

A fortunate byproduct of the study was sampling during a strong young-of-the-year (**YOY**) recruitment episode. Data concerning spatial and temporal patterns of YOY fishes in the *S. caurinus* / *S. maliger* complex was collected during 2000.

Three of the four San Juan Islands Marine Preserves in San Juan Channel contain nearshore rocky reef habitat. A paired non-reserve site was selected for each of the three rocky reef reserve sites to provide similar bathymetry, substrate complexity, algal communities and exposure to oceanographic processes within each pair (Figure 1).

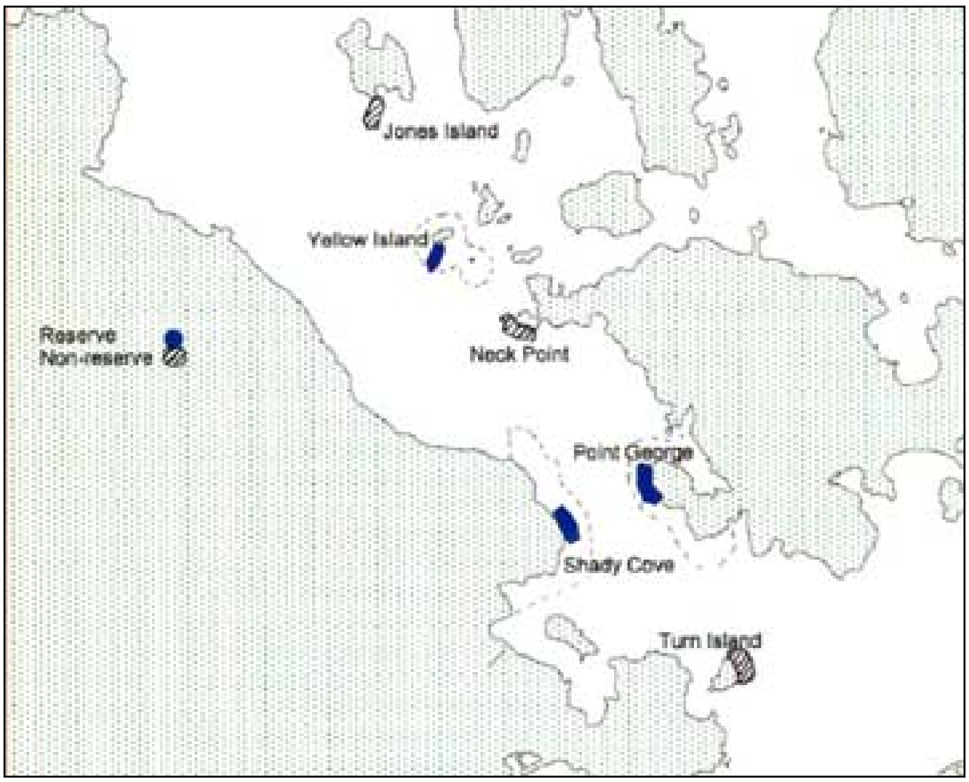

Figure 1. Study sites in San Juan Channel. Dashed lines indicate the boundaries of the San Juan Islands Marine Preserves, established in 1990, which restrict the removal of anything other than salmon, herring, or crab. Reserve sites are solid. Non-reserve sites are cross-hatched. San Juan is on the left, Orcas top right, and Shaw Island middle right.

Methods and materials

Two observers, utilizing SCUBA, completed visual band transects in reserve and non-reserve areas of San Juan Channel. The primary diver was equipped with a depth gauge, thermometer, measuring device, and data recording slate with underwater paper and pencil. The measuring device consisted of a meter-long section of schedule 40 poly-vinyl chloride marked in 5cm intervals with one end attached to a perpendicularly mounted 30cm acrylic ruler (adapted from Paddack 1996). The secondary diver carried a 25m fiberglass tape, 20ml bottles for water samples, compass, data recording slate, paper and pencil. The start of each transect was randomly chosen from a subset of predetermined GPS coordinates, and bearings to conspicuous shoreline features were noted to provide redundancy if survey locations were to be located in the future. Tide Current Predictor software (Pentcheff, 2000) was used to adjust depths for tide height. Any human activity in the area, especially fishing, and its intensity was recorded.

The observers entered the water, descended and checked the anchor line, and proceeded via the most direct route 2m off the bottom to a depth of 13.7m (45ft). Once there, the primary observer was tethered to the end of the fiberglass tape and the secondary observer took a water sample. Next, while staying 2m above the substrate, the primary observer began moving across the reef slope at the rate of 30 fin strokes per minute. During the transect, the primary observer looked left, right, up, down, and searched boulder piles and crevices. The secondary observer remained stationary and held onto the tape reel as it unwound. While swimming the transect, the primary observer noted the depth, total length (to nearest cm), and species for all target species encountered within a 4m x 4m x 4m cube centered on the primary observer. Total length was determined by slowly placing the measuring device directly against or beneath the lateral line of the fish in question, or by measuring the distance between two points on the substrate denoted by “below the tip of the lower jaw and below the posterior portion of the ventral caudal fin ray” (Martell *and others* 2000).

Through practice, the primary observer was able to change depth at a constant slope and end the 25m-long transect at a predetermined depth. For example, during the first 25m x 4m x 4m transect the primary observer would start at a depth of 13.7m (45ft) and end at a depth of 19.8m (65ft) by moving approximately parallel to shore and simultaneously increasing depth as a function of linear distance moved. Potential bias associated with steering towards/away from fish or particular habitats was avoided by focusing only on the immediate 4m x 4m x 4m cube of the transect, and coupling depth gauge readings with sense of body position in the water to maintain a constant rate of depth change.

The secondary observer informed the primary observer when 25m of tape had been let out with three sharp tugs on the tape. Then, it was the primary observer’s turn to remain stationary while the secondary observer reeled up the tape and rejoined the primary observer. As the tape was reeled, the secondary observer passed over the transect and mentally noted habitat characteristics. The secondary observer surveyed habitat of precisely the same 25m x 4m x 4m transect as the primary observer. Habitat data included: strike and dip of the reef slope, substrate complexity (0=sediment, 1=flat rock, 2=cobble, 3=boulder<1m, 4=boulder>1m & <3m, 5=boulder>3m), substrate percent cover (sediments, bare rock, encrusting animals, macroalgae by species), and abundance of macroinvertebrates by species.

When the secondary observer completed reeling, the observers were rejoined and flashed, “OK.” The primary observer then began the next transect while the secondary observer remained stationary (attached to the tape as it unwound) and recorded the data mentally noted during the previous transect. In this way, waiting time was minimized for both observers.

This cycle was repeated 12 times per dive survey, 3 times in each of four depth strata. Therefore, each dive survey consisted of three 25m x 4m x 4m transects via zigzags between stratum bounds in each of 4 depth strata, totaling 12 transects or 1200 sq. meters of rocky reef habitat surveyed and encompassing all depths from 20m to the surface. Over the duration of the study, four surveys were completed at each site, totaling 328 transects. Depth was corrected for tide height such that depths of all transects over all sites and all surveys were uniform with regard to mean lower low water (MLLW).

In summary, this data collection protocol sampled four distinct depth/habitat strata of San Juan Channel nearshore rocky reef, including shallow areas typically inhabited by juveniles as well as deeper habitats (below the lower limit of algal abundance) typically dominated by larger, predatory fish. The protocol provides data for analyses of fish density, which control for microhabitat driven variability in fish abundance. Variance of fish densities per transect can be calculated for each depth stratum of each dive survey. This methodology avoids the often time consuming process of installing permanent leadline transects, and yet can still be used to monitor precisely the same (meter scale) locations on a reef year after year.

Results

Results are graphed as length-frequency distributions. Year 2000 data were grouped by reserve or non-reserve and graphed together for comparison. Historical data was graphed below reserve/non-reserve data on the same horizontal axis. Total numbers of fish in reserves and non-reserves provide abundance estimates as these data resulted from equal sized areas surveyed: 14,400 m^2 for both reserves and non-reserves. However, the vertical axis for historical data is not scaled equivalently to the vertical axis for reserve/non-reserve data and vertical axis labels must be read in order to interpret changes in abundance over time. Vertical dashed lines in the figures indicate lengths at 50% maturity for males, females, or both. Length at 50% maturity is a standard proxy for length at average first maturity (Gunderson, pers. com.).

Lingcod (*O. elongatus*) were larger in reserve sites. Size classes >=55cm were more abundant in reserves while most size classes <55cm were more abundant in non-reserves. The reserve distribution is approximately equivalent to the historical distribution compiled by Moulton (1977) while the non-reserve distribution lacks the larger size classes present in the reserve and historical distributions. Sixty-five and forty-eight *O. elongatus* were sighted in reserves and non-reserves, respectively (figure 2).

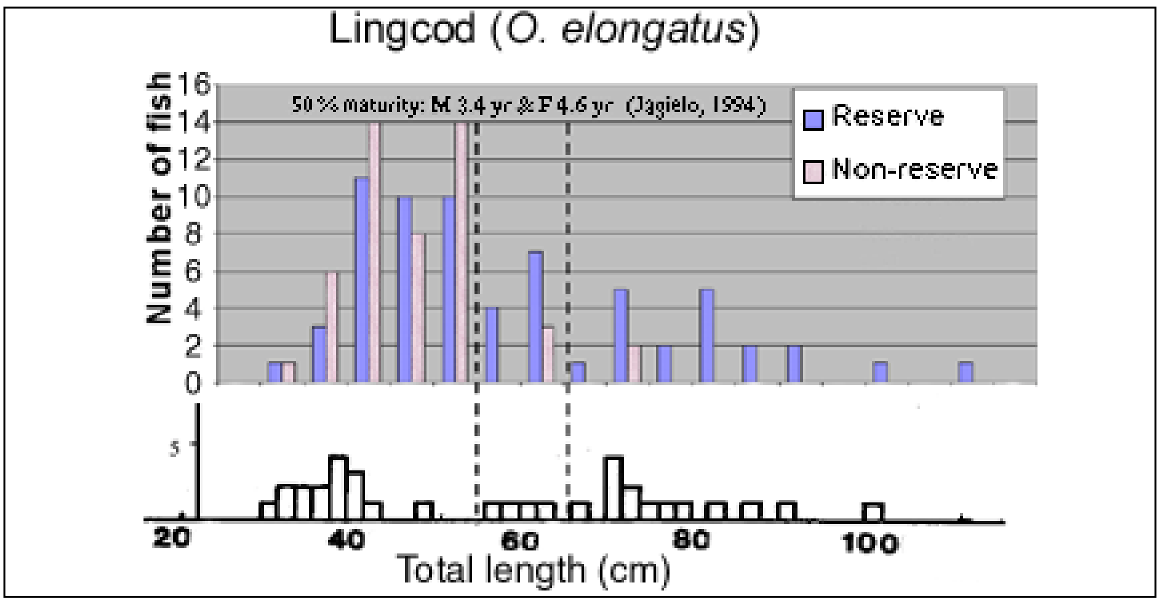

Figure 2. *O. elongatus* length frequency distributions for reserves and non-reserves in 2000 (top) and the same areas in 1974-76 (bottom). Dashed bars indicate lengths at 50% maturity for males (left) and females (right). The lower legal size of the angler slot limit is 26 inches (66.04cm).

Copper rockfish (*S. caurinus*) were larger in reserves. All size classes >=25cm were more abundant in reserves while most size classes <25cm were more abundant in non-reserves. Except for the disappearance of extremely large individuals (38-50cm), the reserve distribution follows the historical distribution of Moulton (1977). The non-reserve distribution is shifted down slightly towards smaller size classes compared to historical and reserve distributions. Individuals <8cm are YOY of the *S. caurinus* / *S. maliger* complex. Due to greater abundance of *S. caurinus*, the YOY were assumed to be mostly *S. caurinus* and included in the *S. caurinus* plot (figure 3).

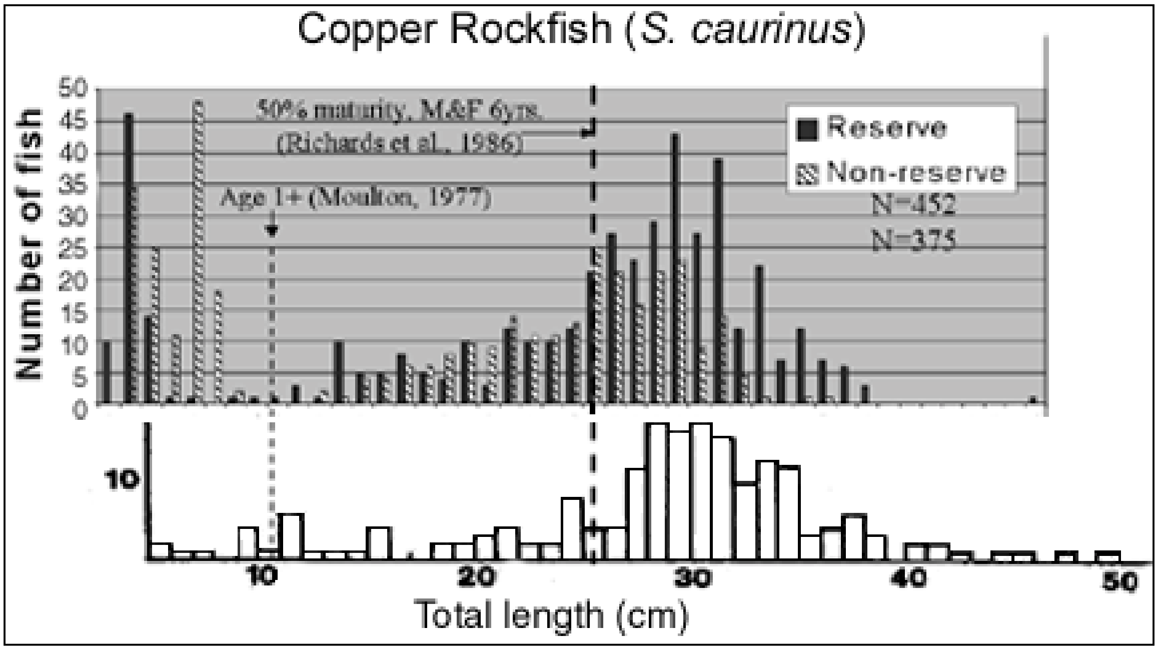

Figure 3. *S. caurinus* length frequency distributions for reserves and non-reserves in 2000 (top) and the same areas in 1974-76 (bottom). Dashed bar on right indicates length at 50% maturity for both males and females.

Black rockfish (*S. melanops*) were found only in reserves. Individuals large enough to reproduce were sighted, however in very low abundance (eleven fish total during 2000). No fish <35cm was sighted. The present low abundance coupled with zero recruitment for approximately six years is sharply contrasted by the historical data (Moulton 1977) that shows a continuous distribution from 15 to 55cm and greater abundance for all length classes (figure 4).

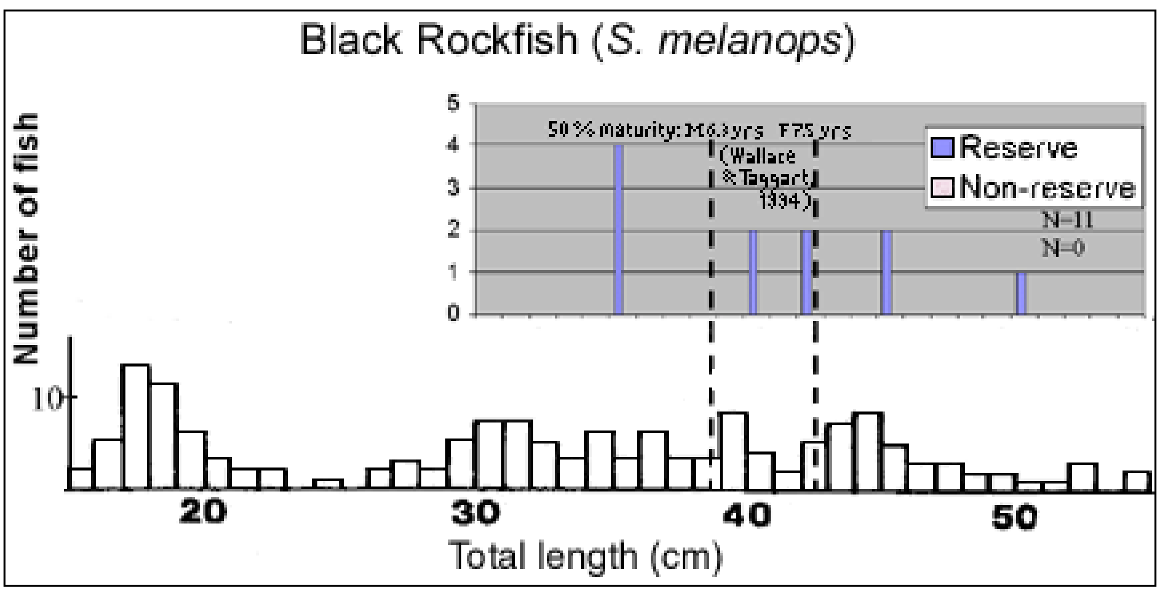

Figure 4. *S. melanops* length frequency distributions for reserves and non-reserves in 2000 (top) and the same areas in 1974-76 (bottom). Dashed bars indicate length at 50% maturity for males (left) and females (right).

Yellowtail rockfish (*S. flavidus*) were also found only in reserves, and as with *S. melanops* abundance was extremely low compared to historical data. All eleven individuals sighted were subadults (non-reproductive) varying in size from 20 to 24cm. Data from the mid-1970s show reproductive individuals and a distribution encompassing all life history stages (Figure 5).

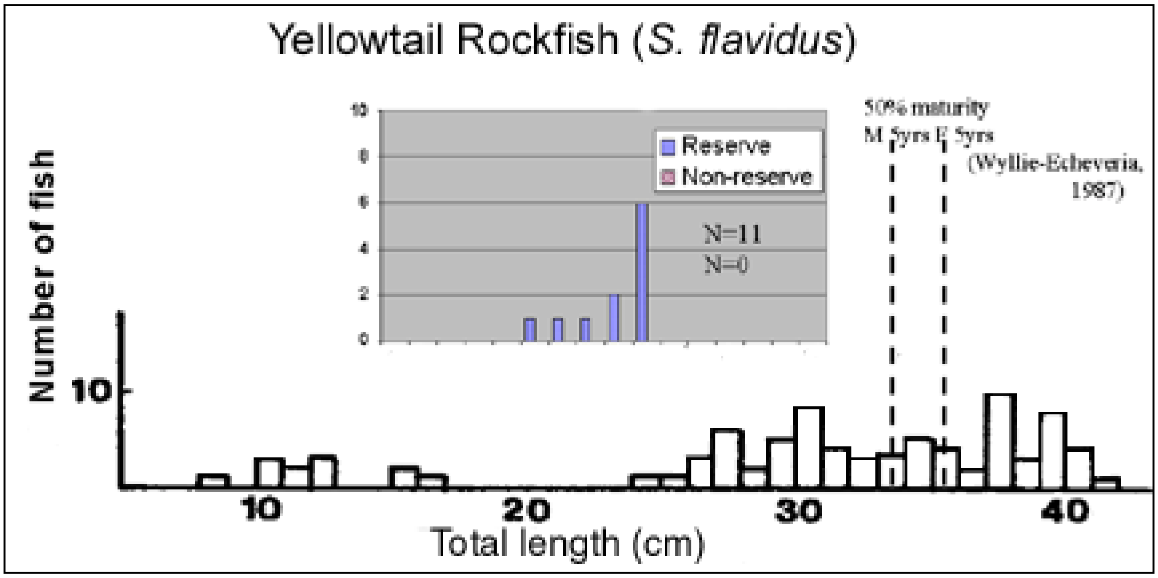

Figure 5. *S. flavidus* length frequency distributions for reserves and non-reserves in 2000 (top) and the same areas in 1974-76 (bottom). Dashed bars indicate length at 50% maturity for males (left) and females (right).

Kelp greenling (*H. decagrammus*) had similar distributions in reserves, non-reserves, and historically (Moulton 1977). In addition, reproductive individuals made up the bulk of all three distributions (Figure 6).

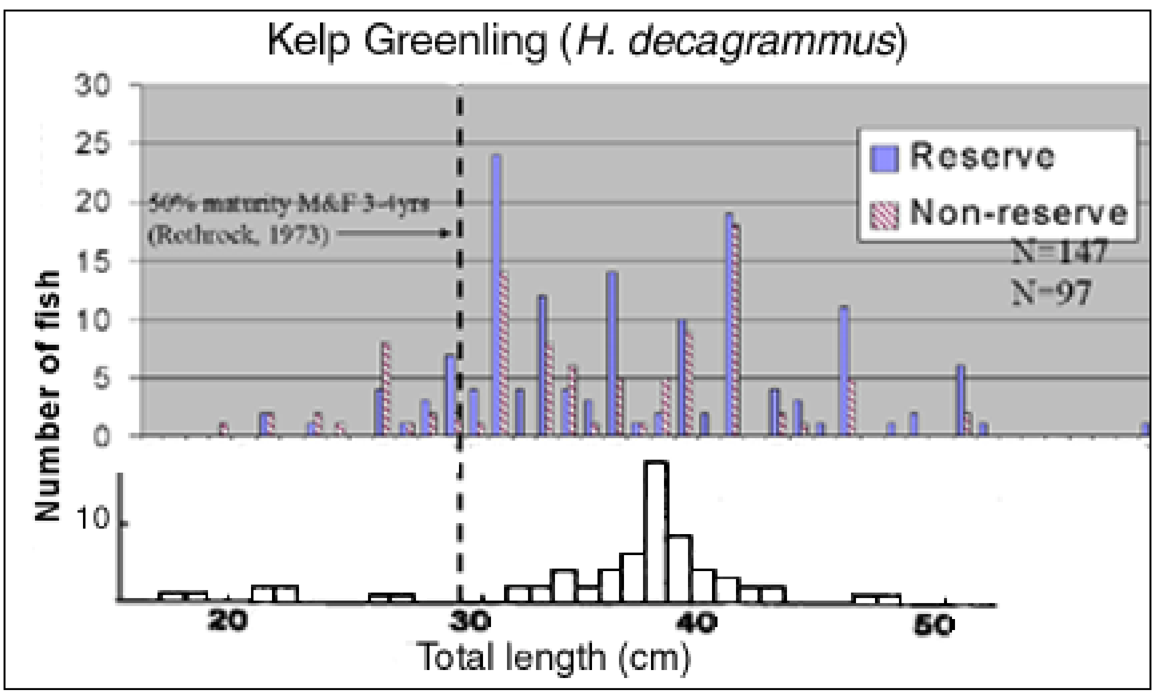

Figure 6. *H. decagrammus* length frequency distributions for reserves and non-reserves in 2000 (top) and the same areas in 1974-76 (bottom). Dashed bar indicates length at 50% maturity for males and females.

Striped surfperch (*E. lateralis*) also had similar distributions in reserves and non-reserves. Unfortunately, no historical data were available for this species. Very few reproductive individuals were sighted, yet recruits were present. In addition, lengths of fish sighted encompassed all life history stages (Figure 7).

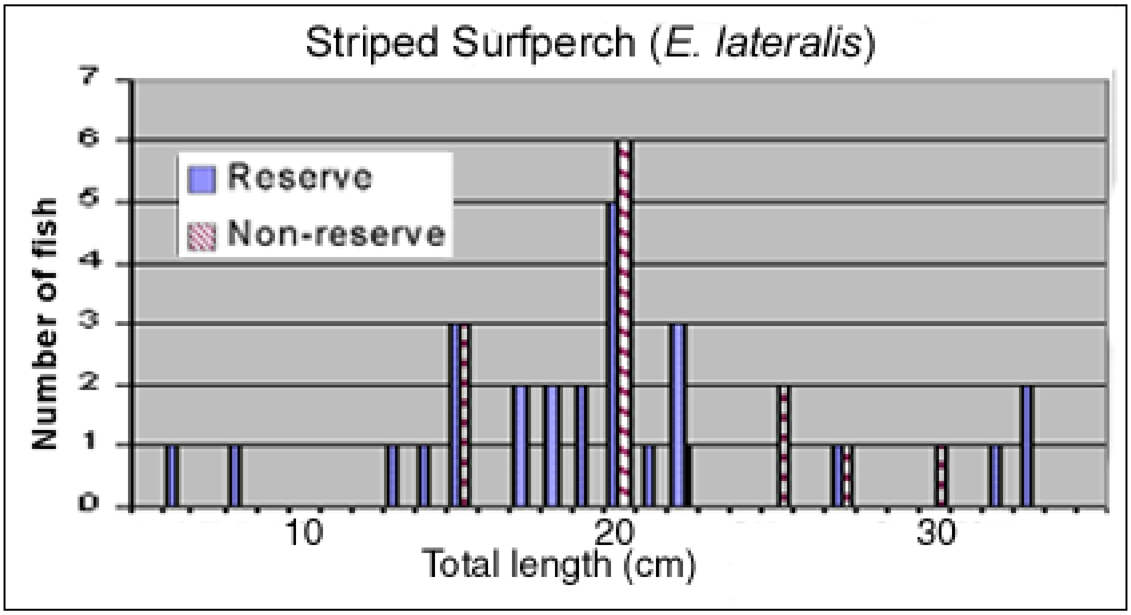

Figure 7. *E. lateralis* length frequency distributions for reserves and non-reserves in 2000. Thin bar indicates length at 50% maturity for males and females. Historical data is unavailable for this species.

Puget Sound rockfish (*S. emphaeus*) were nearly three times as abundant in the non-reserves compared to the reserves. This inverse reserve effect is coupled with much greater *S. emphaeus* abundance in 2000 than in the mid-1970s. Size structure of *S. emphaeus* has shifted downward since the 1970s (Figure 8).

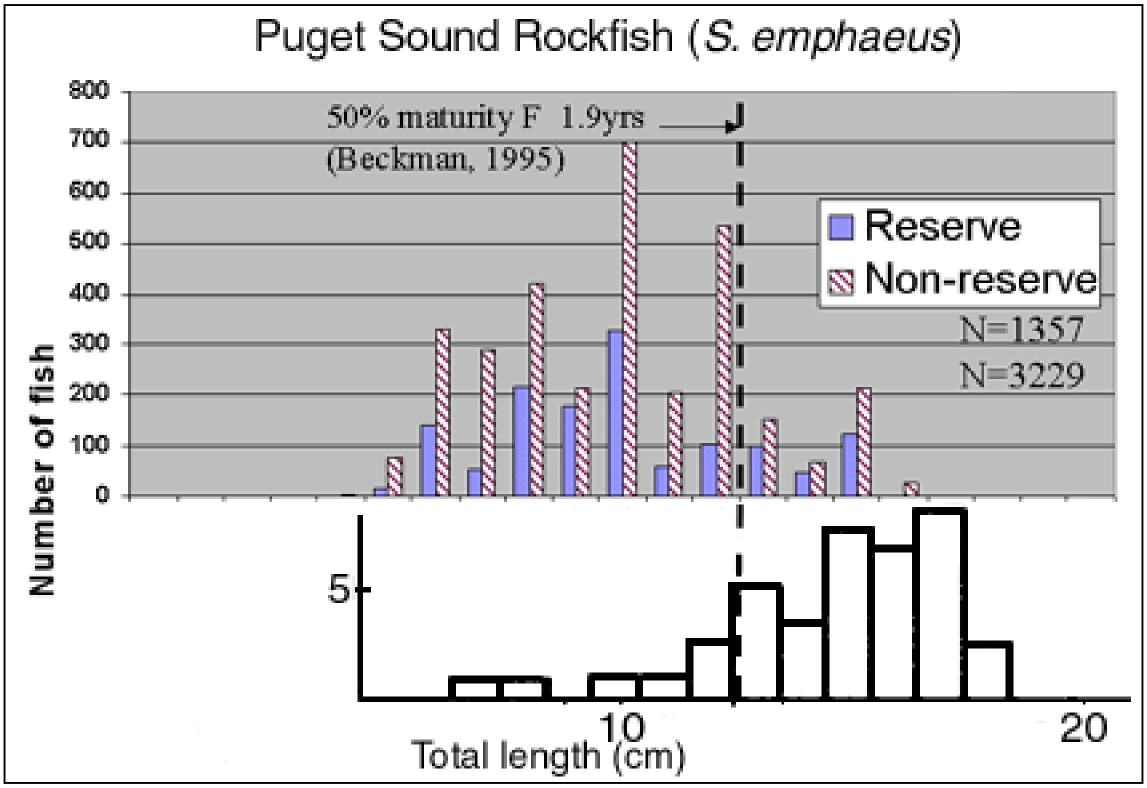

Figure 8. *S. emphaeus* length frequency distributions for reserves and non-reserves in 2000 (top) and the same areas in 1974-76 (bottom). Dashed bar indicates length at 50% maturity for males and females.

Quillback rockfish (*S. maliger*) also showed an inverse reserve effect with more than three times greater abundance in non-reserves than in reserves. The 2000 length-frequency distribution of *S. maliger* was shifted downward compared to historical distributions in the same area by Moulton (1977). In addition, zero reproductive *S. maliger* were sighted in 2000 compared to reproductive fish comprising half the population in the mid-1970s (figure 9).

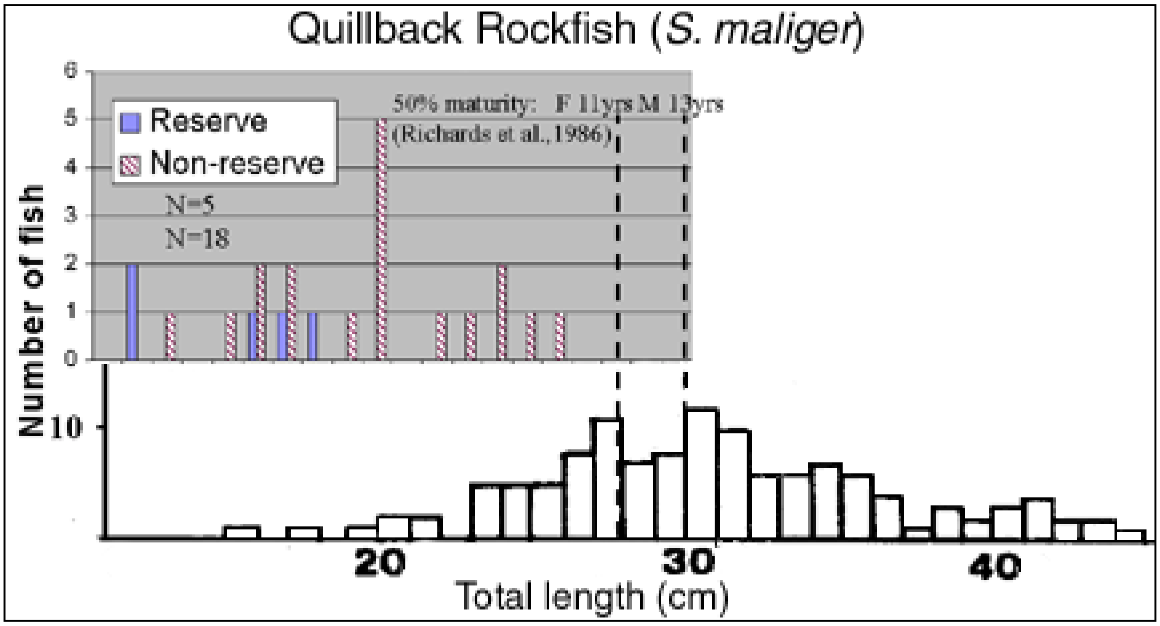

Figure 9. *S. maliger* length frequency distributions for reserves and non-reserves in 2000 (top) and the same areas in 1974-76 (bottom). Dashed bars indicate length at 50% maturity for males (right) and females (left).

Results were species specific. Larger individuals and greater abundance were found for four species in the reserve sites: lingcod (*O. elongatus*); copper rockfish (*S. caurinus*); black rockfish (*S. melanops*); and yellowtail rockfish (*S. flavidus*). These four target species are all highly sought after by anglers and susceptible to fishing mortality. Extremely low abundance relative to historical data by Moulton (1977) of *S. melanops* and *S. flavidus* compromises conclusions of a reserve effect for these two species. Large *S. caurinus* (>38cm), which have been reported to live for up to 55 years (Bloeser 1999), have virtually disappeared since the 1970s. In addition, the length-frequency distribution of *S. caurinus* in non-reserves is shifted to smaller lengths compared to the reserve distribution and the mode of the historical distribution compiled in the mid-1970s by Moulton (1977). Length-frequency distributions of kelp greenling (*H. decagrammus*) and striped surfperch (*E. lateralis*) showed no difference between reserve and non-reserve sites, however both species were slightly more abundant in reserve sites. Puget Sound rockfish (*S. emphaeus*) and quillback rockfish (*S. maliger*) were more abundant and larger in non-reserve sites. More detailed discussion of results for each of the eight target species and their interactions follows in the discussion section.

Abundance and length data concerning YOY of the *S. caurinus/S. maliger* complex was collected at all six sites from the July 27 to October 5. Recruitment varied spatially and was independent of reserve/non-reserve status. In all three cases of reserve/non-reserve pairs, one site had high recruitment and the other had low recruitment. Two non-reserves had high recruitment and one had low recruitment. One reserve had high recruitment and two had low recruitment.

Microhabitat data collected revealed similar microhabitats in reserve/non-reserve pairs. Differences in fish density and length within reserve/non-reserve pairs are not due to differences in microhabitat. Most of the studies cited for lengths at 50% maturity were completed many years ago. Selection for reproduction at smaller sizes and younger ages due to fishing pressure is evident from the length-frequency distribution of *S. caurinus*. Reproductive characteristics, in particular length to fecundity curves, could have shifted over time due to this selective pressure. In addition, most of the studies cited used fish from locations outside the San Juan Islands for determining length at 50% maturity. Species may have different reproductive characteristics at different locations. For these reasons, the vertical dashed bars should be used as rough guides rather than precise indicators.

Discussion

Lingcod (*O. elongatus*) are commonly targeted by anglers and are one the most highly prized and sought after bottomfish in San Juan Channel. Nineteen *O. elongatus* large enough to be reproductive females were found in reserves versus two fish in non-reserves. The two non-reserve fish were both just large enough (70cm TL) to be reproductive females and since reproductive potential increases exponentially with length, these two fish contribute disproportionately less to the reproductive output of the population. For these reasons, most of the reproductive potential for *O. elongatus* must come from fish found in reserves, yet the non-reserves have ample recruits. This indicates a recruitment spillover of juvenile fish from reserves to non-reserves. *O. elongatus* in reserves are augmenting recruitment in non-reserves.

Fewer large *O. elongatus* in non-reserves translates into greater availability of resources (e.g. prey and space) in the non-reserves. These available resources are probably supporting the greater densities of small *O. elongatus* (<55cm) found in non-reserves. In addition, this result validates the assumption of similar habitat contained in each reserve compared to its paired non-reserve site.

The low end of the legal size limit for *O. elongatus* is 26 inches (or 66.04 cm), the same size at which greater fish density shifts from non-reserve to reserve sites. This 'smoking gun' is strong evidence that removals by anglers fishing in non-reserve areas structure demographic pattern of *O. elongatus*. The distribution of *O. elongatus* in reserves is similar to that found in San Juan Channel during the mid-1970s, while the distribution in non-reserves is lacking larger individuals—the broodstock. The network of marine reserves is playing a major role in sustaining *O. elongatus* stocks in the area.

Copper rockfish (*S. caurinus*) are a commonly targeted bottomfish and are often bycatch of anglers targeting lingcod. While there were reproductive adult *S. caurinus* in both reserves and non-reserves, there were more in reserves—especially for larger length classes. Given the exponential increase of *S. caurinus* fecundity as a function of length, more reproductive potential is contained in reserves. A relatively strong cohort of YOY recruits with heterogeneous spatial distribution in both reserve and non-reserve sites during 2000 indicates that larval supply for this portion of San Juan Channel is coming from one common pool. During the spring, *Sebastes* larvae assumed to be *S. caurinus* were most abundant in the middle of the channel and abundance was inversely proportional to distance from shore (Chasco *and others* 2000) further supporting a single larval pool for San Juan Channel. Nearshore bathymetry on the scale of tens of meters appears to drive retention and recruitment of YOY and explain the heterogeneous distribution of YOY.

The virtual disappearance of *S. caurinus* >38cm (one single fish larger than 38cm, was sighted during the 2000 survey, a 45cm individual) should be noted, as fish of this length were much more common at the same sites in the 1970s. This indicates increased mortality of larger, exponentially more fecund individuals since the 1970s, almost certainly due to fishing pressure. The duration of protection needed to regenerate historic levels of abundance of *S. caurinus* individuals >38cm is longer than 10 years, which makes sense for a species that can live to be 55 years old. Given more time, *S. caurinus* >38cm will probably become more abundant in reserves. The network of marine reserves is playing a role in sustaining *S. caurinus* stocks in the area.

Black rockfish (*S. melanops*) are prized by anglers and easily caught by bottomfishers and bycaught by trollers targeting salmon. The lack of individuals <35cm compared to historical data by Moulton (1977) indicates a recruitment limited population in 2000. In the mid-1970s, *S. melanops* was common at the Turn Island non-reserve site (Miller, unpublished data), where they are not currently present. The extremely low abundance compared to historical levels and the disappearance outside of reserves indicates a stock decimated by overfishing. Climate may be a factor as well, although not enough data exists to support the claim. The network of marine reserves is playing a major role in preserving *S. melanops* as a member of the San Juan Channel nearshore rocky reef assemblage, however the continued presence of this species is uncertain.

Yellowtail rockfish (*S. flavidus*) are a commonly taken rockfish. Occurring in schools off the bottom, this mesopelagic species is characterized by extremely patchy distribution. They are prized by anglers and easily caught by bottomfishers and bycaught by trollers targeting salmon. All eleven *S. flavidus* sighted in

2000 were in reserves. Larvae of *S. flavidus* are thought to occasionally drift up the Juan de Fuca Strait and settle in the San Juan Islands. This would explain the presence of subadults without adults, as seen in 2000.

The lack of adult *S. flavidus* compared to the mid-1970s could be the result of fishing pressure but could also be related to climate. Much larger reserves with before and after reserve formation time series data from both inside and out of reserves are needed to differentiate the relative importance of fishing pressure and climate in regulating temporal fluctuations in abundance (Carr and Reed 1993). The network of marine reserves is playing a role in preserving the *S. flavidus* species as a member of the San Juan channel assemblage, however the future demographic trend for this species is uncertain.

Anglers do typically not seek kelp greenling (*H. decagrammus*). Interviewed locals said they do not consider them good eating and usually throw them back. Survivorship of caught and released individuals should be high since this species is most abundant in depths less than 40 feet where air embolism is not a critical issue. In addition, *H. decagrammus* inhabits shallower depths than most bottomfishers frequent. All of these reasons may explain why their distributions are similar in reserves, non-reserves, and historically.

H. decagrammus was the most actively moving target species during dive surveys. Accurate home range information is unknown for this species, although it is possible that *H. decagrammus* moves more than the size of these reserves (2-3km) and therefore the reserves confer a reduced refuge from fishing pressure. This would also explain the similarity of reserve and non-reserve distributions. However, the similarity of distributions from 2000 and the mid-1970s indicates that the more important process regulating this species' demographics is lack of fishing pressure rather than large home range and/or movement rates. In either case, the network of marine reserves is not playing any direct role in structuring *H. decagrammus* stocks in the area.

Striped surfperch (*E. lateralis*) are almost never caught by anglers because their mouths are too small to take a typical bottomfishing hook. A related species, pile perch (*Damalichthys vacca*), inhabits pilings under docks and is commonly caught by anglers specifically targeting them. *E. lateralis* does not typically inhabit these piling areas. The lack of fishing pressure for *E. lateralis* explains similar length-frequency distributions in reserves and non-reserves. The network of marine reserves is not directly affecting demographics of *E. lateralis* in the area.

Puget Sound rockfish (*S. emphaeus*) are almost never caught by anglers because they feed on plankton and their mouths are too small for a typical bottomfishing hook. They also reproduce at around 2 years of age (Beckman 1995) and none were seen greater than 16cm TL. They behave similarly to subadult *S. flavidus* and *S. melanops*, schooling above certain features on rocky reefs and swimming into the current looking for prey. Adult *S. emphaeus* are also approximately the same size as subadult *S. flavidus* and *S. melanops*. Large increase in abundance over time of *S. emphaeus* may be facilitated by decreased abundance over time of subadult and adult *S. flavidus* and *S. melanops* and a resultant increase in availability of space and/or prey resources. However, it is impossible to prove this without showing that prey or space is scarce.

Another potential explanation is that food and space are essentially unlimited and the population bottleneck for *S. flavidus* and *S. melanops* is supply of YOY. This appears to be the case for *S. melanops*. The situation for *S. flavidus* is unclear, and neither of these hypotheses explains why *S. emphaeus* has undergone a huge increase in abundance.

The greater abundance of *S. emphaeus* in non-reserves versus reserves is most likely due to increased predation of *S. emphaeus* inside reserves by more abundant and larger *O. elongatus*. *O. elongatus* were associated with aggregations of the relatively small Puget Sound rockfish, probably because *O. elongatus* are eating them, and there are more and larger *O. elongatus* in reserves. The network plays an indirect yet major role in regulating the density of *S. emphaeus* at the various sites. Human influences are structuring ecosystems directly (in the case of *O. elongatus*) and indirectly (in the case of *S. emphaeus*). There could be unknown indirect impacts on other species, for example killer whales (*Orcinus orca*).

Quillback rockfish (*S. maliger*) are a commonly targeted bottomfish and are often bycatch of anglers targeting lingcod. *S. maliger* behaves similarly to *S. caurinus*, except that *S. maliger* generally inhabits greater depths. The disappearance of reproductive *S. maliger* from the assemblage since the 1970s is most likely due to fishing removals and competition with the steadily increasing population of *S. caurinus* in the area (Moulton 1977; Caselle 1987; Miller 1991; Gregg and Eisenhardt, unpublished data). Competition with *S. caurinus* could be forcing the lower depth limit of adult *S. maliger* deeper and out of conventional SCUBA working depths.

Working depth limitations limited the survey protocol to depths <70 feet. Moulton (1977) surveyed the same depth range as this study and half the *S. maliger* he saw were reproductive size. Reconnaissance dives to 100 ft completed during 2000 found the same abundance (zero) of reproductive *S. maliger* as sighted during all surveys in 2000. Fishing removals are structuring the demographics of *S. maliger*, and the low fish density relative to the 1970s may be further exacerbated by competition with *S. caurinus*. The network of marine reserves is affecting demographics of *S. maliger* indirectly and in adverse ways.

Factors other than reserve/non-reserve status and differences between site pairs, including extreme nearshore (10s of meters-scale and within 10-20m from shore) bathymetry and resultant physical oceanography, appeared to be more important for determining YOY recruit density. Retention in tidal current eddies may be the mechanism driving this process. In addition, mortality of YOY appeared higher in reserves, perhaps due to increased predation and/or cannibalism by more abundant and larger fishes, especially *S. caurinus* and *O. elongatus*, in reserve sites. In terms of marine reserve design, this argues for networks of many smaller reserves and avoiding establishment of reserves in zones of high YOY recruitment.

Three species of rockfish were sighted only in the three sites that exhibited large densities of YOY recruits. These three species were *S. maliger* (also note: all 23 *S. maliger* sighted were subadults), *S. flavidus* (also all subadults), and *S. melanops*. These three sites, which had high YOY recruitment and greater *Sebastes* species abundance, were one reserve site and two non-reserves. Recruitment may be structuring species diversity patterns for the *Sebastes* genus in San Juan Channel.

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